Improvements in and relating to Blast Mitigation Structures

This invention relates to blast mitigation structures which use liquid-filled containers such as water-filled flexible bags, arranged so as to mitigate the effects of a blast or explosion by dissipitating and/or converting to heat the resulting blast energy.

Blast mitigation structures using water-based technology are well known and for instance US patent no. 4836079, the disclosure of which is incorporated herein by reference, teaches various embodiments of bomb blast inhibitors which can be inflated with air, placed around e.g. a bomb, and then filled with water, the water then acting to suppress or otherwise mitigate against the effects of any ensuing explosion. This concept has been taken at least a further step by the use of, effectively, twin-walled containers as taught in GB2374625A, the disclosure of which is also incorporated herein by reference, which include internal connectors between opposing walls and surfaces, such as through the use of drop stitch material, by which the container is prevented from bulging outwardly, the main benefit being that a protective wall can then be erected which is taller than the width of the base without the container collapsing or toppling over under the weight of water.

A problem with such prior art devices is that although they are very efficient in safely dealing with the effects of explosions, given that the containers themselves are not made of rigid material and hence when fragmented by an explosion such fragments do not constitute flying debris equivalent to shrapnel, it will be apparent that the inflation of such structures by air followed by substitution of air under pressure for water under pressure by e.g. the use of a

suitable pressure relief valve arrangement, still necessarily takes some time to complete the structure. In the event of e.g. a car bomb having to be dealt with it will be understood that this may jeopardise the safety of personnel erecting such blast mitigation structures around the car.

The present invention is derived from the realisation that, especially when dealing with potential car bombs i.e. suspect vehicles, speed is of the essence in quickly and safely erecting a blast protection structure around the vehicle using rupturable liquid-filled containers such as water-filled bags, but in conjunction with means for rapidly deploying the containers therearound.

According to the invention, there is provided a blast mitigation structure comprising one or more rigid free-standing frames of one or more channel section, the or each frame being adapted to receive in the or each channel, in use, one or more rupturable containers adapted to contain liquid, such as water, to thereby form a protective tunnel around e.g. a vehicle for mitigating against the effects of an explosion.

Conveniently, the or each rigid frame is in the form of an arch made of some suitably rigid but lightweight material such as e.g. aluminium or reinforced plastics such that even though, following detonation of e.g. a car bomb, such material then disintegrates into flying debris or shrapnel the relatively low mass of each piece thereof provides a correspondingly lower risk of injury or damage, as the case may be.

The or each rigid frame may suitably include apertures therein, such as by being in the form of a grill, the exposed parts of the or each rupturable container thereby being in the direct path of the explosion such that rupturing of

the exposed surface area of the or each container occurs simultaneously with damage caused to the or each rigid frame by the explosion.

Conveniently, opposing sidewalls of the or each channel section of the or each rigid frame extend only partially around opposing side walls of the or each rupturable container such that where two or more of such frames and corresponding containers are placed side-by-side they touch beyond this region. Hence, as they rupture during an explosion the containers prevent or inhibit the sidewalls of the channels from flying off following an explosion without at least being partially restrained by the presence of the water and/or the flexible material from which the rupturable containers are made.

Conveniently, the blast-suppressing structure is transportable and may even take the form of a wheeled vehicle which may be moved, such as by being towed or pushed by a powered vehicle over and around a suspect device or vehicle, as the case may be. Alternatively, where the structure is intended to be formed by a series of rigid frames placed adjacent each other to form an arched tunnel each such arch and associated rupturable container or containers may be placed on individual trolleys connectable with others, such as those used to transport luggage around airports.

As will be apparent, an arched tunnel structure necessarily implies open ends and, accordingly, the invention also envisages the use of free-standing water-filled rupturable containers being positioned at each open end so as to provide an entirely closed structure when the assembly is complete.

The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a schematic perspective view of part of a blast mitigation structure in accordance with the invention,

Figure 2 is an end view of the structure of Figure 1 showing a vehicle therein,

Figure 3 is a schematic sectioned view of part of the structure of Figures 1 and 2,

Figure 4 is a schematic sectioned view of an alternative embodiment to that shown in Figure 3,

Figure 5 is a schematic sectioned view of a further alternative embodiment to that shown in Figures 3 and 4,

Figure 6 is a side elevation of part of a blast mitigation structure in accordance with a further embodiment of the invention,

Figure 7 is an end elevation of part of a blast mitigation structure in accordance with a still further embodiment of the invention,

Figure 8 is a schematic side view of individual elements making up a blast protection structure in accordance with the invention being transported,

Figure 9 is a side elevation of a fully constructed blast mitigation structure in accordance with one embodiment of the invention, and

Figure 10 shows an alternative embodiment of a blast mitigation structure to that shown in Figure 9.

Referring firstly to Figures 1 and 2 an arched structure shown generally at 1 is composed of individual segments of free standing arched rigid frame sections 2 having channels into each of which are placed individual inflatable

bags 3 shaped to fit therein such that, as will be apparent, initially these bags are generally rectilinear but become arched towards the top of the structure 1.

In Figures 3, 4 and 5 are schematically shown various alternative embodiments of structures having profile frame section for making up the arched structure 1. In Figure 3, the profile of the rigid sections 2a is such that they are connected together to form a length of connected channels in which side walls 4 are shared by adjacent inflatable bags 3. In addition, apertures 5 are provided in the bottom of each channel section 2a such as being in the form of a grill so that, following an explosion, the side walls of the bags 3 in this region are exposed thereto and, as a consequence, water contained in the bags 3 is then able to mitigate against the effects of the explosion even while the rigid frame caused by the presence of the channel section 2a remains intact momentarily.

In Figure 4 an alternative profile is proposed in which each rigid frame section 2b is shown capable of accommodating, in this embodiment, a total of three lines of bags 3 which are retained in their respective positions by virtue of return lips 6 which help retain the outer most bags 3 in position. Each rigid frame section 2b is capable of being butted up against an adjacent frame section 2b as shown in the drawing and hence whilst still being transportable can be used to quickly form the structure shown in Figures 1 to 2.

In Figure 5 there is an alternative embodiment in which instead of individual rigid frame sections 2b as shown in Figure 4, each able to accommodate three lines of the bags 3, the rigid frame sections 2c shown may be of any desired length, having individual channel sections to accommodate any desired number of bags 3.

In Figure 6 there is shown a side view a completed arched tunnel with an alternative arrangement in which the side walls 4a of each frame section 2d do not support the entire side walls of the bags 3 but instead allow the bags to "close in" around the walls 4, such that no rigid elements are visible outwardly other than at the ends of the respective tunnel. In this embodiment, it is envisaged that, following an explosion, flying debris from the rigid structure made up by the individual channel elements 2d has to pass through the wall of bags 3 in the region where they overlap such that there is at least some suppression of some or all of the resultant flying debris.

In Figure 7 there is shown an end elevation of a further alternative embodiment of the invention which envisages the use of hoses strategically placed around the inside walls of the rigid frame sections 2, 2a, 2b, 2c, and 2d which may be interconnected or interconnectable with each other and with the bags 3 such that upon the structure 1 being assembled the bags may thereafter be quickly filled with water to complete this part of the assembly of the entire blast mitigation structure.

In Figure 8 is shown schematically an arrangement by which individual rigid frame sections 2 with attendant bags 3 may be transported on e.g. luggage trolleys as conventionally used at airports. Larger bags 8 may be individually transported and may be used for particular applications, such as blocking holes or in combination with other such bags surrounding small bombs.

In Figures 9 and 10 are shown two alternative but complete blast mitigation structures of the type shown with reference to e.g. Figure 1 but in which the ends have been blocked by means of self-supporting inflatable bags.

These are initially filled with air in order to attain their required shape and then through the use of pressure relief valves the air is replaced with water under pressure to thereafter maintain the desired shape. In Figure 9, the bags 3a are pneumatically interconnected and include internal reinforcements, such as by being made of drop stitch material, to maintain the desired shape, in this example a stepped structure of shape sufficient to close the arched structure 1.

In Figure 10 a different configuration is adopted where the bags 3b collectively define when inflated a right angled triangle in section, where bag forming the hypotenuse is used as reinforcement to ensure that the structure does not collapse.